U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News

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Optical Methods of Studying Pressure Effects . . . page 79

U.S. DEPARTMENT OF COMMERCE — LUTHER H. HODGES, *Secretary*

NATIONAL BUREAU OF STANDARDS — A. V. ASTIN, *Director*

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Contents

COVER: Interferometric method for studying the effects of pressure on the refractive index of liquids was developed in a general investigation of the effects of pressure on various materials. The prime purpose of the investigation is to develop a better understanding of intermolecular forces. (See p. 79.)

Improved Glass Dewar Flask

for Low-Temperature Research

A GLASS DEWAR [1] that retains liquid helium up to 10 hr after an initial filling of 1.2 liters has been developed by L. J. Schoen and H. P. Broida. This flask is smaller, simpler, less expensive to fabricate, and more rugged than previous glass Dewars, and can be adapted for use in a variety of low temperature investigations.

The first double-walled glass vessel having a highly evacuated space between the walls was developed by James Dewar in 1892. This basic design has proven to be the most effective means of insulation yet devised. Various modifications have, of course, been introduced since the original development, such as silvering the glass to reduce heat transfer by radiation, placing a radiation shield between the walls, and surrounding the double-walled inner flask with an outer flask of liquid nitrogen refrigerant. Other structural adaptations include provision for pumping on the refrigerant to further reduce the temperature, and inclusion of viewing windows to permit observation of frozen gases and radicals.

Glass Dewars previously developed by the Bureau [2] have been based on a double-Dewar design, with a liquid-nitrogen-filled flask almost completely surrounding the inner flask. This type of construction, however, is somewhat bulky and less rigid than desired. New designs have therefore been fabricated and tested in an effort to make a smaller and simpler but equally effective Dewar.

The most promising of the new designs consists of an inner double-walled flask of which only the upper portion is surrounded by a liquid nitrogen jacket. Shielding below the nitrogen jacket is provided by a copper cylinder which is suspended from and cooled by the nitrogen reservoir. The construction of this Dewar permits easy disassembly for cleaning and repair, and new shields and housings can be fitted for different experiments. Measurements on this Dewar's storage properties show that after precooling to 77 °K an initial filling of 1.2 liters of helium lasts about 10 hr.

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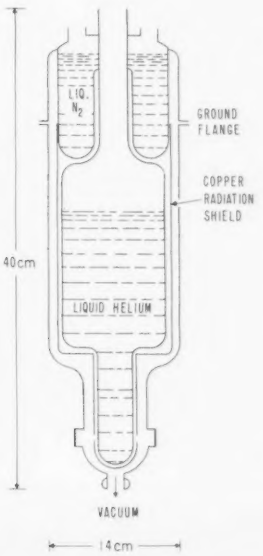
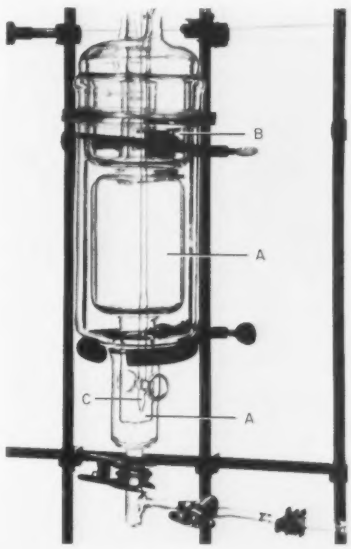
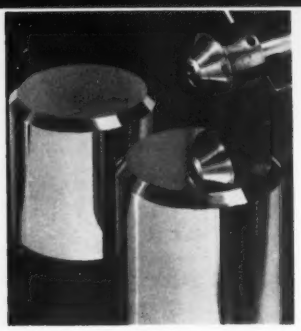
[1] Glass Dewars for optical and other studies at low temperatures, *by L. J. Schoen and H. P. Broida, Rev. Sci. Instr.* **33,** 470 *(April 1962).*

[2] Glass Dewars for optical studies at low temperatures, *by L. J. Schoen, L. E. Kuentzal, and H. P. Broida, Rev. Sci. Instr.* **29,** *633 (1958).*

Left: **Lois Frolen assembles the improved Dewar flask. The copper radiation shield can be seen inside the portion on the right. After assembly the space between the glass walls is evacuated through the fitting at the bottom.** *Right:* **Liquid helium fills space "*A*," and reservoir "*B*" is filled with liquid nitrogen. Copper radiation shield** *(not shown)* **attaches to the nitrogen reservoir and surrounds the helium space. Samples of gas to be studied are frozen at the bottom of tube "*C*," and observed through the viewing windows. This Dewar retains liquid helium up to 10 hr after initial filling.**







DIAMOND BURNISHING

gives high finish to laboratory weights

SURFACE FINISH is an important characteristic of standard weights. Rough surfaces tend to obscure particles of dust and dirt present on the surface, and also to increase surface area, which may influence mass constancy.[1] On the other hand, high finishes make surface particles readily visible and reduce gross surface area. The Bureau has been seeking a rapid, reproducible means for achieving a smooth hard finish on stainless steel, which is frequently used in fabricating laboratory weights. Recent work by W. E. Vaughn and J. R. Hettenhouser of the Bureau's instrument shops shows that Hull's simple diamond burnishing technique [2] gives the desired results.

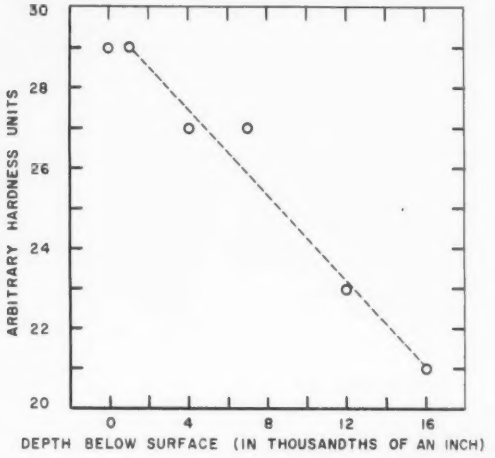
Stainless steel cylindrical bars were initially cut on a tool room lathe to a diameter and a length of 2.145 in. (dimensions of one type of a standard weight). The resulting surface finish was found to be smooth to within 20 μin. A tool containing a spherical diamond, 1/4 in. in diameter, was then positioned on the lathe so that it could be held rigidly against the metal during the burnishing process.

Various spindle speeds and machine tool feeds were tried in the course of the work. For the turning of the specimen, that is, for burnishing its cylindrical surface, an effective spindle speed was found to be 400

Results of tests conducted by E. H. Hull [2]

Original surface roughness	Roughness after burnishing	Improvement ratio, Col 1 / Col 2
μ *in. average*	μ *in. average*	
10	3	3. 3
10	3	3. 3
30	4½	6. 7
30	2¼	13. 3
60	4½	13. 3
60	3	20
120	6	20
120	3	40

Top of page: **Two laboratory weights given high surface finishes with a diamond burnishing technique. The diamond tool used** (*upper right*) **is reflected in one of the mirrored surfaces.** *Left:* **W. E. Vaughn positions the diamond tool mounted on a tool room lathe so that the proper angle is obtained in burnishing the face length of a laboratory weight.** *Below:* **Typical gradient of hardness found for one of the stainless steel specimens near the surface. Before burnishing, parent material hardness was about 15.**



rpm, with a feed of 0.6 in./min. On the face lengths or ends of the specimen, the best results were obtained with a spindle speed of 290 rpm and a feed of 0.5 in./min. To prevent galling of the metal surface, generous applications of a lubricant (10-percent trichloroethylene in sulfur-cutting oil used in this instance) were found necessary.

Specimens fabricated in this manner met the surface finish requirements for laboratory weights. They had a hard surface finish with an average smoothness to within 3 μin. Long-term tests are now under way to investigate the suitablity of the diamond burnishing method for fabricating scientific reference mass standards.

[1] Metals Handbook, *1948 ed. (p. 558)*; *and* Corrosion of Metals, *by C. W. Borgmann et al., American Society for Metals, Cleveland (1946).*

[2] Diamond burnishing, *by E. H. Hull, ASME paper No. 61–WA–96 (1961).*

STANDARD MATERIALS

Plutonium Standard Sample

In cooperation with NBS, the Atomic Energy Commission has prepared a chemical standard sample of plutonium [1] for use by educational and research institutions and industry in the United States and abroad. Having a purity of 99.97 percent, the plutonium sample (NBS Standard Sample No. 949) can be utilized as a comparison standard for all plutonium chemical analyses.

Development of standard materials of accurately known composition has long been a major interest to users of atomic energy materials. In recent years the considerable expansion in the users of atomic energy has underlined the need for standard materials on which to base measurements of high precision and accuracy. To meet this demand, the Commission, with the aid of committees drawn from industry, has cooperated with the Bureau to establish a continuing program for providing the needed standard materials. The first results of the AEC–NBS cooperative program were a series of 15 uranium isotopic standards and a natural uranium chemical standard which became available from the Bureau in 1958.

The plutonium standard was produced at the Los Alamos Laboratory of the AEC at Los Alamos, N. Mex., by bomb reduction and then purified by electrorefining. Three standardization methods were used to evaluate the purity of the material. In one method, which was an amperometric titration, plutonium IV was oxidized to Pu VI by argentic oxide, and then reduced to Pu IV with ferrous ammonium sulfate which had been standardized against an NBS standard sample of potassium dichromate. In the second method, which was a potentiometric titration, Pu IV was reduced to Pu III by zinc amalgam and then oxidized back to Pu IV by ceric sulfate, which was standardized against an NBS standard sample of sodium oxalate. In the third method, also potentiometric, Pu IV was oxidized to Pu VI by perchloric acid, and then reduced back to Pu IV with ferrous ammonium sulfate, which had been standardized against an NBS standard sample of potassium dichromate. Results from all three methods were in close agreement.

Each plutonium standard sample consists of about one-half gram of plutonium metal sealed in a glass ampoule under reduced argon atmosphere. The exact certified weight of each sample is marked on the ampoule.

The standard samples, supplied by NBS for $34.00 per sample express collect, are available in the United States only to persons licensed by the Commission and to AEC contractors. Standards are available to foreign countries whose governments have appropriate agreements for cooperation with the United States.

Domestic orders must be placed on Order Form NBS–285, which may be obtained from the National Bureau of Standards, Washington 25, D.C. Orders from foreign sources should be submitted on Form NBS–285A (also obtained from NBS) to the Division of International Affairs, U.S. Atomic Energy Commission, Washington 25, D.C.

New and Reissued Radioactivity Standard Materials

A new radioactivity standard sample—cobalt 57—and three reissues of previously available standards—zinc 65 and two concentrations of sodium 22—are now being distributed by the Bureau.[1] All are in solution form except the zinc standard, which is prepared as a point source deposited on mylar film.

Cobalt 57 (Standard Sample No. 4941), available in solution form (about 5 ml), is an electron-capturing nuclide with a half-life of 270 days and a nominal activity of 3×10^4 dps/ml (disintegrations per second

Radioactivity standard materials

Sample No.	Nuclide	Activity as of December 1961	Form	Half-life	Price
4921–B	Sodium 22	15×10^3 dps/ml	solution (3 ml)	2.59 years	$21.00
4922–C	Sodium 22	15×10^4 dps/ml	solution (5 ml)	2.59 years	30.00
4941	Cobalt 57	3×10^4 dps/ml	solution (5 ml)	270 days	31.00
4922–B	Zinc 65	4×10^4 γ/s	point source	244 days	30.00

per milliliter). It is used extensively in Mössbauer-effect experiments and as a tracer in vitamin B–12 studies.

The reissued zinc 65 (NBS Standard Sample No. 4992) is available as a point source standard. It has a nominal activity of 4×10^4 γps and its half-life is 244 days. Both sodium 22 standards (NBS Standard Sample Nos. 4921–B and 4922–C) have a half-life of 2.59 years. Sample No. 4921–B, available in 3 ml solution, has a nominal activity of 15×10^3 dps/ml whereas Sample No. 4922–C, which is prepared in 5 ml solution, has an activity of 15×10^4 dps/ml.

The cobalt 57, zinc 65, and one sodium 22 standard (Sample No. 4921–B) may be ordered singly under the general licensing provision of the Atomic Energy Act of 1954, and may be purchased for $31.00, $30.00, and $21.00, respectively. The other sodium 22 standard (Sample No. 4922–C), however, may be ordered only under the special licensing provisions of the 1954 Act. A copy of the purchaser's current AEC By-Product Material License should therefore be on file at the Bureau to purchase that sodium sample for $30.00. All orders for the radioactivity standards should be addressed to Miss Elizabeth M. Zandonini, Radioactivity Standard Samples, Radioactivity Section, National Bureau of Standards, Washington 25, D.C.

Pendulum-type tear tester used to measure the average internal tear resistance of paper. As part of the test procedure Henrietta Brown initiates a cut in a paper specimen.

Tearing Strength Standard for Paper

A new standard material [1] is being issued by the Bureau to increase the accuracy of measuring the internal tearing strength of paper. The paper standard (NBS Standard Sample No. 704) is designed for calibration of testing instruments and is more uniform than ordinary commercial papers. It was developed as part of the Bureau's continuing program to standardize test methods.

To obtain predictable best results in service, the physical properties of paper must be closely controlled. During the recent several years, the increasingly stringent requirements imposed by modern high-speed manufacturing and converting processes, the extension of paper uses under extreme climatic and other conditions, and the development of radically new types of paper have intensified the need for standardizing methods used for measuring physical properties of paper. The test for tearing strength is necessary to determine how different types of paper will handle during the converting processes employed, for example, to print newspapers or to prepare envelopes, paper bags, or cable wrapping paper.

To facilitate the development of uniform test methods throughout the paper industry, the Institute of Paper Chemistry (IPC) conducted a preliminary survey. As a result of this study, the American Paper and Pulp Association (APPA) and the Technical Association of the Pulp and Paper Industry (TAPPI) requested assistance from the Bureau in obtaining standard test methods for various properties of paper.

The first phase of the Bureau's research, directed by T. W. Lashof, has produced the standard paper samples for measuring internal tear resistance. Interlaboratory experiments, with over 40 participating groups, showed that the use of this standard material greatly reduced variations in tear strength values within and among laboratories.

Sheets from a selected portion of a run of commercial paper of high uniformity are used to prepare the

standard samples. To assure even greater uniformity between sets of samples, the large sheets are randomly mixed by automatically dealing them three times into a different number of piles. Then the paper is cut in half to produce 6-in. by 9-in. sheets and collected in packages of 120. Each sheet is sufficient for 6 plies.

To use the standard sample, an operator would prepare a specimen of 16 plies—each ply taken from a different sheet. The 16 plies are clamped together in the jaws of the tear tester after they are cut to the proper length, as explained in the instructions distributed with the sample. Following this, the tear is made in the specimen and the energy used (tear strength) is recorded.

The initial distribution of the standard material will be made in a set of 12 packages. One package from the set will be shipped at approximately monthly intervals. Laboratories will be asked to report their results to the Bureau. From the results obtained during the first few months, the Bureau and APPA–TAPPI Reference Materials Committee will recommend the optimum frequency for using the standard material.

The standard samples will serve as an overall control for the tear tester. They will provide a check on the instrument, environmental conditions, and procedural variables—all of which may affect the internal tear strength value. The tear strength of the standard is obtained from specimens preconditioned for a minimum of 24 hr at about 12 percent R.H. (relative humidity), 23 °C, and then conditioned for a minimum of 24 hr at 50 percent R.H., 23 °C. The certified average value will be issued with each sample.

The standard sample may be purchased for $4.00 per package or $48.00 for a set of 12 monthly packages from the National Bureau of Standards, Standard Sample Unit, Washington 25, D.C.

New Standard Materials Publication Available

The Bureau has recently issued *Standard Materials,* Miscellaneous Publication 241, a catalog [2] which lists the standard materials available from the Bureau with their prices, shipping weights, and directions for ordering. Summarized tables of analyses are also presented to indicate the types of standards of composition presently available. The publication may be obtained for 30 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

Over 600 different standards of metals, ores, ceramics, chemicals, and hydrocarbons are cataloged in the publication. The materials are classified by use and type of certification, if any, that is given. Some of the principal uses of NBS standard materials are: Checking, developing, evaluating, improving, and standardizing analyses and analytical techniques and methods, and standardizing and calibrating various laboratory and plant instruments.

The first small group of chemicals certified by the Bureau with respect to their chemical composition were called "standard samples." Gradually the term was extended to similar composition standards, then to materials certified as to chemical purity or some physical or chemical property, and finally to certain materials that are issued without certification of composition or properties. Now, all are included under the designation "standard materials."

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[1] *Standard samples are described in NBS Miscellaneous Publication 241,* Standard Materials. *This publication may be ordered for 30 cents, from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Up-to-date supplementary inserts, which are issued periodically, are available upon request directly from the National Bureau of Standards.*

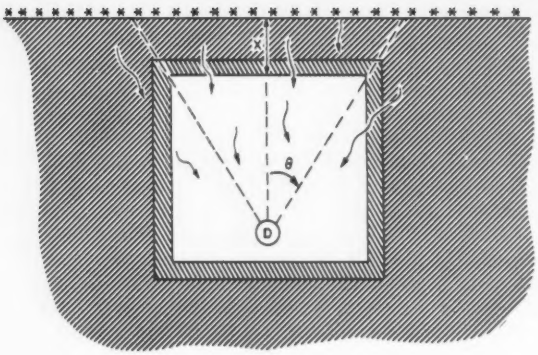
[2] *This publication supersedes* Standard Materials, *NBS Circular 552, 3d edition.*

Structure Shielding Against Fallout Radiation

THE BUREAU has for several years been engaged in experimental and theoretical studies of fallout radiation. With the sponsorship of the Defense Atomic Support Agency and the Office of Civil Defense, the Bureau program in this field has been directed largely towards developing means of assessing the protection afforded by various types of structures. Under the direction of L. V. Spencer of the radiation theory laboratory, procedures have been developed by which protection factors can be determined for a large number of different configurations.[1]

The major Federal emphasis in nuclear protection changed in 1958 from protection against blast and fire to protection against fallout radiation. Bureau participation in the program has centered on theoretical and mathematical studies of fallout protection; the procedures resulting from this investigation will be useful in designing new protective structures, analyzing the shielding capabilities of existing buildings, and assessing the possibilities of improvising shelters.

The detonation of a nuclear bomb, besides producing large-scale blast and fire effects, results in the libera-



An elementary radiation penetration study—the below-ground shelter. Radiation from the ground penetrates to the detector Ⓓ mainly through the roof, although some radiation enters through the walls. The thickness of the roof (X) and the solid angle subtended at the detector by the roof are the parameters of primary importance; corrections for side-wall penetration and back-scattering must be considered. In an actual shelter, the entranceway would be a special maze-type problem.

tion of great quantities of radioactive material. This material is swept high into the atmosphere, to return to earth in a fashion determined by particle size and wind conditions. The precise distribution of the fallout, both in an overall sense and locally (e.g., does fallout settle evenly on all sides of a building, or are shadows created in the distribution pattern? Does it cling to vertical walls, tree leaves, etc.?) depends on conditions at the time of the burst. For purposes of analysis, it is assumed that fallout material is distributed uniformly over exposed horizontal surfaces.

The radiation from fallout materials consists of three components: gamma rays, electrons, and alpha particles. The latter two can be overlooked in radiation protection calculations because of their very limited range of penetration. They do constitute a hazard, however, if taken internally in contaminated food or water. Since gamma rays travel long distances through air, and can penetrate substantial depths of solid material, protection against this radiation is the major concern in assessing fallout shelters.

The radioactive materials resulting from a nuclear explosion arise either from fission products or from the action of neutrons, released by the explosion, on other materials. The radiation from the latter source has not been considered in the Bureau analyses. The spectral quality of the fallout gamma radiation is not constant, but varies with time after the explosion as certain radioactive materials are exhausted and others formed through decay. The spectrum estimated to exist 1.12 hr after fission is that on which Bureau estimates have been made. In addition, data for cobalt 60 and cesium 137 radiation have been included.

Gamma rays travel in straight lines until they collide with an atom. The collision of a gamma ray and an atom results either in absorption of the ray, or scattering of the ray with reduced energy. Because of the long paths in air, the majority of gamma rays within a structure will be scattered by the walls, floors, and objects in a room.

In order to assess the radiation protection to be expected from a particular set of conditions, the radiation at a "standard unprotected position" is used as a reference. For this purpose, the response of a detector located 3 ft above a hypothetical source of the same character as fallout is used. It is assumed that the source is at a smooth, infinite plane interface. The reduction factor (reduction in radiation intensity or "attenuation") is defined as the ratio of the detector response in the protected position to the response in the standard unprotected position.

The reduction factor as measured within a structure is separated into two components: barrier reduction, due to the attenuation resulting from the passage of gamma rays through a barrier, and geometry reduction, the attenuation resulting from all other features of the configuration. Barrier shielding depends upon many factors, including the composition and density of the barrier material, the gamma-ray spectrum, and the directional distribution of the incident radiation. These factors are taken into account in different ways: The 1.12 hr spectrum is the only fission spectrum for which data are included; but different source directional distributions have been used in deriving data. Composition and density of materials are treated by using a barrier thickness variable X, called the effective mass thickness, proportional to the number of electrons per square foot of the barrier.

Included in geometry factors are such considerations as (1) the apparent size of the wall as seen from the detector, expressed as the solid angle fraction subtended at the detector by the radiation source (usually the wall); (2) wall thickness (which has an effect in addition to attenuation in that, as the thickness increases, directional distributions of gamma rays change); (3) the shape of the wall and the position of the detector; and (4) source type.

Shape dependence is accounted for by representing actual situations as superpositions of simpler, different source shapes. Thus, estimated geometry factors for a set of "standard shapes" can be combined to approximate most of the shapes encountered in practice.

The dose D measured at a particular point within a structure is the sum of the contributions entering through various wall sections and the ceiling. Each of the contributions includes a barrier factor and a geometry factor, the geometry factor consisting of one or more terms corresponding to partial surfaces used to represent the total actual surface. Mathematically,

$$D = D_0 \sum_i B(X_i) \left\{ \sum_j G(X_i, \omega_{ij}) \right\}$$

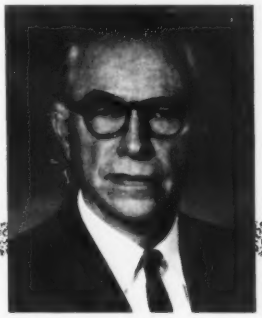
where D_0 is the detector response at the standard unprotected position, B is the barrier factor of effective mass thickness X, and G is the geometry factor of

thickness X and solid-angle fraction ω. Essentially, the analysis of a structure involves methods of estimating barrier factors B and geometry factors G.

Computer programs were established to solve transport integral equations and generate data for six types of barrier factors and nine types of geometry factors. A series of graphs (total of close to 80) was plotted for easy reference; those graphs pertaining to fallout radiation were plotted for cobalt 60 and cesium 137 data also.

The data prepared by the computers can be used, along with other theoretical treatments, to determine the detector response in a variety of common elementary barrier arrangements. Expressions have been developed which, by using basic data, protection factors can be determined for such configurations as barrier interfaces, foxholes, shelters covered with fallout, vertical walls, shielded basements (in-and-down problem), and mazes.

[1] Structure shielding against fallout radiation from nuclear weapons, *NBS Mono. 42, available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., for $.75. Other publications dealing with the problem of structure shielding include* Design and review of structures for protection from fallout gamma radiation *and* Guide for architects and engineers, *both available from the Office of Civil Defense, Department of Defense.*



Dr. Edward Wichers Retires

ONE OF THE WORLD'S outstanding authorities on analytical chemistry, Dr. Edward Wichers, retired from the Bureau on March 31. Dr. Wichers was an Associate Director for the last four of his 44 years at the Bureau.

Within the past year, Dr. Wichers saw the completion of one of his favorite projects when the physicists and chemists of the world agreed on a single scale of atomic weights. Dr. Wichers was a major influence in the unification. Prior to the adoption of the new scale, physicists and chemists used tables of atomic weights differing by about 275 parts per million. The new scale is based on carbon 12.[1]

During his career at the Bureau, Dr. Wichers centered his interest on platinum metals, rare earth elements, reagent chemicals, and pure substances. He contributed to the development of a complete system for analyzing the platinum metals. His efforts in the analysis of chemical reagents, including the specifications now governing their purchase, are credited with bringing about major improvements in the quality of reagent chemicals used in this country. The standard work on this subject by the American Chemical Society Committee on Analytical Reagents, of which Dr. Wichers was Chairman, is one of his major achievements.

While Chief of the NBS Chemistry Division, Dr. Wichers established the Pure Substances Section. The efforts of this group are largely responsible for NBS achievements in the highly important field of pure substances.

Dr. Wichers' membership in various professional societies and scientific organizations, national and international, indicates the range of his interests in chemistry. In addition to his previously mentioned Chairmanship of the Commission on Atomic Weights, he has been President of the Chemical Society of Washington, and has held important posts in the American Chemical Society. Currently, Dr. Wichers is President of the Commission on Physico-Chemical Data and Standards of the International Union of Pure and Applied Chemistry, and for many years was a member of the Bureau of IUPAC. He has also served as President of the Inorganic Chemistry Section of the Union.

In 1920, three years after his arrival at NBS, Dr. Wichers was appointed Chief of the section dealing with platinum metals and chemical reagents. From 1948 to 1958 he was Chief of the Chemistry Division.

Among the many awards and honors presented to Dr. Wichers were the 1938 Hillebrand Prize of the Washington Section of the American Chemical Society (received jointly with Dr. Raleigh Gilchrist), and an Exceptional Service Award from the U.S. Department of Commerce in 1952.

Born in Zeeland, Michigan, in 1892, Dr. Wichers received his B.A. from Hope College in 1913 and his M.S. and Ph. D. degrees from the University of Illinois in 1915 and 1917, respectively.

[1] *See* New unified scale adopted for atomic weights, *NBS Tech. News Bull.* **46**, *p. 34 (Feb. 1962).*

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Recording Phys

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Analog-to-digital converter-recorder system. Input preamplifiers and monitoring strip chart are at left. Analog circuitry and timing circuitry are in the sloping-front cabinets, with the power supplies below, while the cabinet on the right contains the magnetic tape transport and the converter circuitry.

A METHOD for using computers to study the reactions of the human body to psychological stimuli has been developed at the Bureau. The method employs equipment that accepts simultaneous, rapidly occurring psychophysiological measurements in analog form, converts them to digital form, and records them on magnetic tape for later computer processing. The electronic circuits to drive and interconnect a standard analog-to-digital converter and recorder were designed for the Air Force Office of Scientific Research by a team which included E. S. Sherrard, of the NBS data processing systems division, and Herbert Zimmer a psychologist at the University of Georgia. Although intended to record the responses of subjects in a continuing psychological investigation, this equipment can be useful for multichannel recording in many biological applications which yield rapidly changing analog data. Such applications include studies of psychological conditioning, reactions to drugs, and autonomic responses to emotions and situations.

Studies in experimental psychology often require measurements of subjects' reactions to psychological stimuli. Where autonomic responses are being studied, the subject may be unable to describe or time the stimuli or to appraise objectively his responses, some of which he may not even be aware of. Recording several simultaneously occurring and sometimes rapidly changing reactions has been one of the technical problems in the study of autonomic reactions. Medical instrumentation has provided transducers to measure autonomic conditions of the human body, but a means of recording the data for later study and tabulation has been needed.

Use of a polygraph—such as a "lie detector"—has filled the recording need in some cases. This instrument records body responses to each of a series of stimuli—questions put to the subject—as measurements inked directly onto a moving roll of graph paper, ideal for easy inspection of the responses of individual subjects. The tabulation of these data to meet the system requirements could be accomplished by a computer, but the raw data supplied by the transducers would have to be put in digital form for computer use.

The converter-recorder method was developed to record, for later statistical treatment, psychological data—subject reactions to visual stimuli given at 30-sec intervals—acquired on a "production line" basis. It scans the continuously measuring transducers at a 0.1-sec repetition rate; since successive converted readings for any analog channel show little change they are, in effect, continuously presented measurements. The record for each stimulus consists of measurements during the 20-sec post-stimulus period, which are compared against the baseline supplied by measurements of the same conditions during the 10-sec pre-stimulus period.

Physiological Measurements for Data Processing

Analog Data Handling

The converter-recorder will handle eight channels of analog measurements and two channels of pulse-coded session and time identification data. The following physiological conditions are measured by the transducers used: Skin resistance, respiratory movements of the chest, respiratory movements of the diaphragm, integrated muscle action potential, time interval between R–spikes of an electrocardiogram, pulse amplitude, skin temperature, and integrated shifts of body weight.

The analog signal in each channel is amplified by a preamplifier selected or designed for signals having the characteristics of that analog measurement. Six of the analog signals are also presented continuously on a strip-chart recorder for on-the-spot observations and initial equipment adjustments.

Conversion and Digital Recording

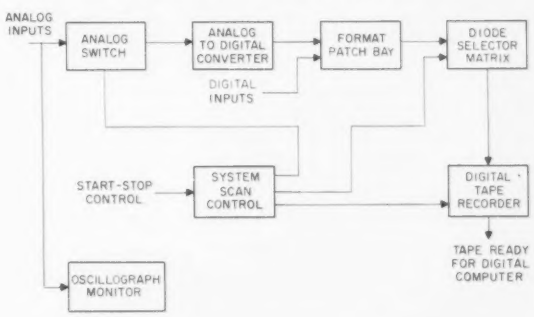
Both analog data and the digital session and time data are scanned by the converter at a 10-msec-per-channel rate to convert each analog channel to an 11-bit binary-coded digital signal. The 11 bits of digital information for each analog channel can accommodate integral numbers from -1024 to $+1024$ for a zero-centered range, for example. The digital signals obtained are buffered and again converted, this time to a maximum of five words of 36 binary digits each; this information is supplied to a diode-selector matrix via 180 leads.

The diode-selector matrix functions to connect successive groups of six digital lines to the six parallel heads which record the digital signals on magnetic tape. The matrix has a format of five words, each with six characters of six bits each; it is scanned at a character rate of 300 c/s to attain a word rate of 10 per second.

The six channels of information plus one channel for parity check are recorded on half-inch tape driven continuously at 1.5 inches per second. The tape transport used accommodates 10-in. reels for recording 12 half-hour experiment sessions—a full work day.

The seven-channel recorded tape is the end-product of the data converter-recorder; the information recorded on it is ready for use by a digital computer. In its preparation the presence of an operator is required only for initial checkout of the equipment, selection of the film strip which serves as the stimulus, and attachment of the transducers to successive subjects. The treatment of these data by a digital computer can eliminate all repetitive manual computation and minimize steps needed for statistical analysis.

Analog-to-digital converters and digital recorders are used for a variety of projects, especially where statistical treatment of the data is to follow. The present converter-recorder will be useful for recording several simultaneous channels of continuously read analog data, or mixed continuous and discretely quantized information (analog and digital), provided only that the reading repetition rate is compatible with the greatest rate of variable change. The six-hour duration of a single reel of magnetic tape makes it particularly convenient to record and store a day's measurements.



Analog-to-digital converter-recorder system, showing functions used to convert analog inputs to digital form and record the digital data on magnetic tape. The diode selector matrix is scanned to drive six parallel recording heads; these six tracks and one track for parity check are recorded on half-inch magnetic tape. Up to ten channels of input information (eight of them analog information) are recorded by this device. The tape is later used as the input to the digital computer which performs computational operations on the body of physiological data.

Boundary-Layer Effects on Shock-Wave Pyrolysis

AN INVESTIGATION by the Bureau has shown that boundary-layer effects, if not properly accounted for, can lead to erroneous conclusions in shock-tube experiments. K. E. McCulloh and R. E. Ferguson of the molecular kinetics laboratory, in a study of the shock-wave pyrolysis of propane, found that under their experimental conditions the extent of decomposition remained constant, despite changes in reflected shock-wave temperature. The explanation of this phenomenon is that a portion of the reactant is lost to the boundary layer, where it is unavailable for reaction.

This work was part of a study of the thermal decomposition of propane. In earlier experiments, difficulty had been experienced in evaluating the role of surface reactions in the chain decomposition. In an attempt to avoid this difficulty, and to extend observations to temperatures and reaction times comparable with those occurring in flames, pyrolysis was studied using the shock-wave technique. This was done by creating a shock wave in a narrow, propane-filled tube, and utilizing the reflected wave (from the end of the tube) to heat the propane sufficiently to cause decomposition. The reaction products were then analyzed quantitatively.

Experimental Apparatus

A Pyrex tube 120 cm long and 25 mm i.d. was used as the low-pressure reaction vessel. A diaphragm of 1-mil cellophane separated the reaction tube from the helium driver gas, maintained at 1.3 atm and 300 °K in a brass tube. The cellophane diaphragm was punctured with a solenoid-driven needle to initiate a run. The reaction gas used in all cases was a mixture of 90 mole percent argon and 10 mole percent propane (C^{13} labeled). Initial pressures of the reaction mixture ranged from 3.3 to 7.5 mm Hg, depending on the shock strength desired.

To permit analysis of the reaction products, the gases could be pumped through two liquid-nitrogen-cooled traps. The first of these traps collected condensables for gas chromatography; the second contained a molecular sieve to retain argon and methane.

The speed of the incident shock wave was determined from oscillograms which recorded signals from three shock-wave detectors located along the reaction tube. The detectors used were thin-film nickel oxide resistors.[1] Measurements indicated that the shock-wave deceleration was negligible, being less than one percent in 20 cm of travel.

Results

The analyses of the products resulting from three runs at different pressures (see table) indicate that the fraction of propane decomposed is independent of the temperature behind the reflected shock wave. This result occurs because a portion of the reactant gas tends to concentrate in the boundary layer near the wall. As reaction in this experiment occurs only behind the reflected shock wave, gases lost from the main stream to the boundary layer will be unavailable for reaction. As no indication of such departure from uniform flow was gained from an examination of shock-wave velocity measurements, it is evident that shock-tube pyrolsis results should not be interpreted on the basis of velocity measurements alone. At present, it is difficult to estimate the diameter of the shock tube or the higher pressure that would be needed to reduce the loss of gas to the boundary layer to acceptable limits.

[1] Nickel oxide thin-film resistors for low pressure shock wave detection, *by K. E. McCulloh, Rev. Sci. Inst.* **31**, *780 (July 1960)*.

Results of three experiments on decomposition of propane by the reflected shock-wave technique

	Run 1	Run 2	Run 3
Shock wave speed (incident)—*mm/μsec*	1. 12	1. 19	1. 31
Calculated temperature behind reflected shock—*°K*	1, 800	1, 960	2, 260
Propane (initial)—*cm³ NTP*	0. 581	0. 414	0. 255
Propane (final)—*cm³ NTP*	. 283	. 204	. 127
Fraction decomposed	. 513	. 507	. 502
Products			
Ethane—*cm³ NTP*	. 029	. 014	. 006
Ethylene—*cm³ NTP*	. 197	. 142	. 077
Acetylene—*cm³ NTP*	. 019	. 031	. 041
Propylene—*cm³ NTP*	. 036	. 015	. 004

Optical Methods of Studying Pressure Effects

THE BUREAU is conducting a research program to develop a better understanding of intermolecular forces. One phase of this study is an investigation of the effects of pressure on various materials. An unusual feature of the program is the adaptation of optical methods to make measurements of pressure-dependent properties.

Birefringence, or double refraction, results when a variety of vitreous materials is subjected to uniaxial loading. A polarimetric method has been adapted by R. M. Waxler and L. H. Adams to study the effects of hydrostatic pressure on the decay of induced birefringence.[1] Also, an interferometric method has been developed by Mr. Waxler to study the effects of pressure on the refractive index of liquids.

Polarimetry

Birefringence can be produced in most transparent vitreous materials by uniaxial compression. When the compressive force is removed, most of the birefringence decays within 24 hr. The amount of birefringence produced by a certain stress, and its rate of decay, can be determined by taking successive measurements of the associated optical path difference in the material being studied.

A birefringent material can be used in conjunction with a quarter wave-plate in such a manner as to produce optical rotation. With the arrangement of light source, filter, polarizer, specimen, and quarter wave-plate used in this study, the plane of polarization of incident light is rotated through an angle equal to one-half the phase lag produced in the specimen. The resultant azimuth is determined with an analyzer, so the determination of optical path-difference is reduced to the measurement of angular displacement. Using a polarimeter developed by Goranson and Adams,[2] a sensitivity of ± 0.05 millimicrons has been achieved.

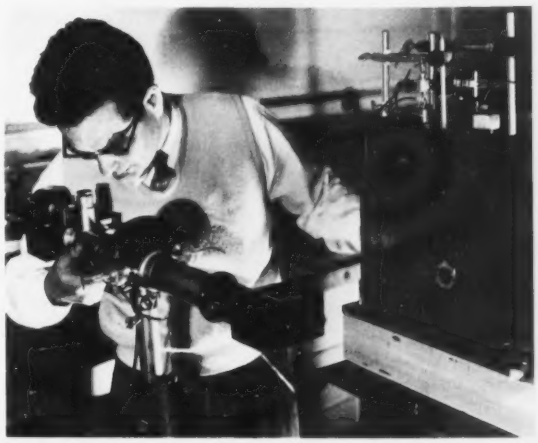
In this study, birefringence was induced in small blocks of plastic by loading them in an electrically driven hydraulic press to 350 kg/cm^2 (allyl diglycol carbonate) or 750 kg/cm^2 (polymethyl methacrylate) for 16 hr. To determine the effects of hydrostatic pressure upon the decay rate of birefringence, stressed samples were taken directly from the press and cut in two, and one of the halves from each sample was placed in a pressure vessel designed for pressure to 10,000 bars. After this half had been subjected to pressure in the vessel for 6 hr, its phase lag was measured and compared with that of the other half of the specimen. It was found that as the hydrostatic pressure increased the rate of relaxation decreased, with no recovery taking place at 10,000 bars.

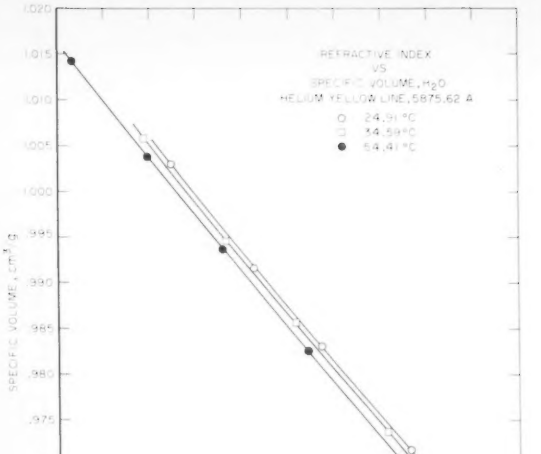
To insure that the hydrostatic pressure itself was not producing birefringence, unstressed samples were subjected to a pressure of 10,000 bars for 10 min, after which no phase lag could be detected.

As direct observations could not be made on the specimens while they were being subjected to pressure in the above apparatus, a second pressure vessel,[3] having observation windows, was also used. This vessel was submerged in a constant-temperature oil bath, which in turn had observation windows. To protect the observer, a total-reflection prism was placed in the optical system so that the analyzer was out of line with the windows.

Stressed, uncut specimens, after having been allowed to relax in air for 2 hrs, were placed in the vessel and pressure was applied. Direct measurements again showed that the rate of relaxation decreases with increasing pressure, and it was shown that a fourth-power law for relaxation holds at elevated pressure.

R. M. Waxler uses interferometric method to determine the effect of pressure on the refractive index of various liquids. The liquid under study is subjected to pressure in a pressure vessel contained in the box at the far right, and the fringes are counted visually. Alternatively, the fringes can be recorded photographically, with as many as 8 lines being determined simultaneously.





Relation between specific volume (a function of pressure) and index of refraction of water. It was found that the refractive index of water is not a function of specific volume exclusively, but that there is a small temperature dependence also.

Previously, this relationship had merely been assumed to be valid. Measurements at different pressures were also made over a short range of temperatures.

Relative mobilities versus pressure were calculated from the observed data. It was found that below 1,000 bars the relation between the reciprocal of mobility and pressure is linear, and that above this pressure the relative mobility decreases enormously. Over the limited range of temperatures studied it appears that the pressure dependence of relative mobility is not affected by temperature.

Interferometry

The effects of pressure upon the refractive indices of benzene, carbon tetrachloride, methanol, and water were also determined in the pressure vessel. Changes in refractive index to five decimals were measured with an interferometer [4] up to pressures of 1,000 bars and over a small range of temperatures.

The refractive index of each liquid under study was determined with an Abbé-type refractometer at atmospheric pressure and at the temperatures to be used during the high-pressure measurements. The liquid was then introduced into a cylindrical cavity in a stainless steel bar. Optical flats, one half-silvered on the back and the other a front-surface mirror, formed the ends of the cylinder, providing a Fizeau-type interferometer. A small hole, bored up through the bar and into the cylinder, was used for filling and to transmit pressure. To prevent contamination of the material being tested, a layer of mercury was interposed between it and the oil of the pressure vessel.

The pressure vessel was immersed in an oil bath and the temperature, measured with a platinum resistance thermometer placed near the sample, was held constant to within ± 0.02 °C. The yellow monocromatic light (5875.62 A) from a helium spectral lamp was used as a source. The pressure on the liquid was increased, and the number of fringes passing a reference mark in the interferometer was determined. In this particular apparatus, the change in refractive index per fringe equalled 1.1028×10^{-4}. As one-tenth of a fringe could be estimated, the refractive index was determined to within $\pm 1 \times 10^{-5}$. Corrections were made for the compressibility and expansivity of the steel cell.

Results of the pressure-refractive index measurements indicate that as the pressure increased the refractive index also increased. However, it was found that the refractive index of water is not a function of specific volume exclusively; at constant specific volume there is a small temperature contribution (see graph).

It is thought that a change in refractive index with pressure may be attributed to a change in density, shift in absorption spectrum, or change in transition probability of optical electrons. Recently a technique was developed for photographing simultaneously the shift in interference fringes for several lines in the visible region of the spectrum. Two spectral lamps, helium and cadmium, are used jointly as a light source, and measurements are made on eight individual lines ranging from the helium red (6678.15 A) to the cadmium violet (4678.16 A). This technique provides data on the dispersion of light in the liquids being studied, and may provide further insight into the intermolecular forces that influence the index of refraction.

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[1] Effect of hydrostatic pressure upon the relaxation of birefringence in amorphous solids, *by R. M. Waxler and L. H. Adams, J. Research NBS* **65A** *(Phys. and Chem.), 283 (1961).*

[2] A method for the precise measurement of optical path-difference especially in stressed glass, *by R. W. Goranson and L. H. Adams, J. Franklin Inst.* **216,** *475 (1933).*

[3] The compressions of certain salts in water, glycol and methanol, *by R. E. Gibson, J. Am. Chem. Soc.* **59,** *1521 (1937).*

[4] An apparatus for photographing interference phenomena, *by J. B. Saunders, J. Research NBS* **35,** *157 (1945) RP1668.*

NBS and University of Colorado Establish Joint Institute for Laboratory Astrophysics

THE UNIVERSITY OF COLORADO and the Bureau announced on April 13 the collaborative establishment of the Joint Institute for Laboratory Astrophysics (JILA) on the CU campus at Boulder, Colorado.

JILA will be a unique permanent academic unit devoted to research and advanced training of students in areas of physics and astrophysics vital to the expanded U.S. space program.

In simplified terms, astrophysics is the application of physics to problems of astronomy. "Laboratory astrophysics" emphasizes laboratory research and theoretical investigations rather than the acquisition of astronomical observations, via observatories, rockets, balloons, and other means.

The new Institute will:

(1) Provide a center for advanced research, bringing together scholars from many fields of physics and astronomy for exchange of ideas and data.

(2) Train graduate and postdoctoral students in atomic physics and astrophysics, fields important to the conquest of space.

(3) Provide stipends to bring outstanding scientists from the U.S. and abroad to JILA for periods up to a year.

(4) Work closely with the existing extensive research programs of the NBS Laboratories for Astrophysical and Plasma Research in both the Washington and Boulder laboratories.

Lewis M. Branscomb, Chief of the NBS Atomic Physics Division, and eight other NBS atomic physicists will move to Boulder this summer where JILA will be set up in temporary quarters in the former state Armory building on the campus.

This Washington group, together with two astrophysicists now at the NBS laboratories in Boulder—R. N. Thomas and J. T. Jefferies—and a group of CU scientists headed by Professor Wesley Brittin, Chairman of the Physics Department, will be the initial professional staff of JILA.

Branscomb has been elected chairman of the Scientific Council which will guide the activities of JILA until January 1964. The council is composed of both NBS and CU scientists.

The Institute will be closely allied with the CU physics department. A number of CU faculty members will be Fellows of the Institute. Many of the NBS scientists will participate actively in the academic program.

CU now is working in several areas which will fit into the JILA program. These include plasma physics, space physics work, and the nuclear physics research on the University's cyclotron. Academically, the institute, in cooperation with the CU physics department, will train graduate students in atomic physics and astrophysics, fields in which there is an acute shortage. Within a few years JILA is expected to consist of 50 senior scientists and 50 postdoctoral fellows and graduate students.

Branscomb

Early planning calls for the erection of a $1.5 million building on the campus to house JILA permanently. Long-range plans envision this structure as a wing of a future CU physics building.

Program

In astrophysics, the Institute will emphasize theoretical rather than observational work and concentrate most heavily in those areas in theoretical astrophysics having the closest coupling with low-energy physics. The principal initial emphasis in astrophysics will lie on stellar atmospheres, gaseous nebulae, and the interstellar medium, but a broad coverage of astrophysics will be encouraged. The approach is expected to emphasize basic physical principles and the physics of the astronomical medium. Although the availability of high-quality observations of the solar spectrum at all wavelengths permits a more detailed and complete treatment than is possible in stellar spectra, and suggests a major focus of effort on solar problems, the Institute will vigorously pursue a broad program of investigation of physics of stellar atmospheres under all conditions. Planetary atmospheres (including the high atmosphere of the earth) are also of great interest to the Institute and studies of this problem depend, equally with stellar problems, on atomic and molecular data. However, it is anticipated that theoretical work in this area will be maintained at a more modest level in the Institute, since other institutions in the community (National Center for Atmospheric Research, NBS Boulder Laboratories, and the Department of Astro-Geophysics of the University of Colorado) are heavily involved in these fields.

In atomic physics, statistical physics, fluid mechanics, and gas dynamics, the basic physical principles will again be emphasized. In atomic physics, heaviest emphasis will be placed initially on appropriate atomic, electronic, and ionic collision cross sections; on atomic resonance phenomena and lasers; on ultraviolet and visible atomic spectroscopy; on oscillator strengths and continuous absorption coefficients; and on ionic reaction rates. The objective of the atomic physics group will not be to determine parameters upon request of astrophysicists (which may occur, but is not practicable in general) but to develop basic concepts and techniques in atomic physics. While gaining greater familiarity with astrophysical problems, the atomic physicist can take advantage of those opportunities that do occur to match a capability in the laboratory to a particular need of the astrophysicist. It is hoped that the experimental atomic physics group will make its greatest contribution to the improvement of theoretical techniques in atomic physics, so that the main production of data for use by astronomers can be done theoretically. Research and the training of students in physics and in astrophysics are equally important and the responsiveness of the work in these fields to astrophysical needs is expected to come about through informal day-to-day contact between staff members of the Institute.

In fluid physics, some examples of problems of great interest to the Institute are radiation transfer problems, line broadening and relaxation mechanisms, the treatment of the coupling between aerodynamic dissipative mechanisms and the radiation fields through which energy is lost, departures from local thermodynamic equilibrium in shock waves, etc. The primary objectives of the Institute relate to aerodynamics through the area of hypersonic aerodynamics treated from the microscopic point of view.

Background

The Space Science Board of the National Academy of Sciences in 1960 adopted a resolution stating, in part: "The Board foresees that a strong limitation to progress in physical interpretation of experiments and observations of the terrestrial, planetary, solar and stellar atmospheres is the lack of sufficient understanding of basic physics of atoms and molecules in the environment which they encounter in these atmospheres. The Board feels that basic work on atomic cross sections, reaction rates and interaction with radiation fields both individually and cooperatively should be encouraged wherever interest exists or may be stimulated."

The Bureau responded to this need by establishing a coordinated group of Laboratories for Astrophysical and Plasma Research, which encompasses the activities of about 100 senior staff members. JILA expects to maintain close working contact with these laboratories, particularly the Atomic Physics Division.

At an International Conference on the Physics of Atomic Collision Phenomena in Boulder, Colorado in June 1961, three distinguished scientists (M. J. Seaton, C. Pecker, and A. Dalgarno) addressed themselves in detail to the requirements of astrophysics and aeronomy for atomic data. Their remarks clearly established the needs and opportunities for a strong program in laboratory astrophysics, and in some ways set the tone for the objectives of the Institute.

The International Astronomical Union, whose commissions have for many years recognized these needs and stimulated research in spectroscopy and related subjects, has reorganized its Commission on Wavelength Standards, Line Intensities and Molecular Spectra into a new commission entitled "Commission on Fundamental Spectroscopic Data." A major responsibility of the new commission, chaired by C. M. Sitterly of the NBS spectroscopy laboratory, is the stimulation of work in laboratory astrophysics along the lines to be pursued by JILA.

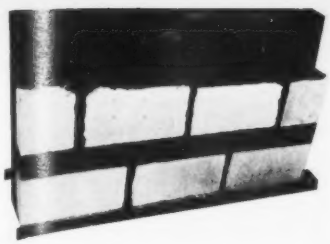
In the preliminary planning and thinking concerning JILA, the following factors have received important consideration:

(1) The collaboration of atomic physicists with theoretical astrophysicists in an attack on the physical basis for the interpretation of astronomical observations is extremely fruitful, and promises to become more so through the full exploitation of the resources of modern physics.

(2) There is at the present time an acute shortage of both low-energy atomic physicists (particularly spectroscopists) and theoretical astrophysicists. The universities are training relatively few students in theoretical astrophysics and atomic physics, largely because of the demands of observational work and high-energy and solid state physics. Of the trained workers in this field, a large fraction are in government and industrial research; many of them work at NBS and are not training students to replace themselves.

(3) The projected manpower requirements of the NASA space program are so great as to compel the immediate expansion of university teaching and research in laboratory astrophysics. The nearly saturated capacity of the best established universities clearly indicates the desirability of expanding and elevating to top academic quality astrophysics and atomic physics programs at the developing schools. Opportunities for rapid expansion of the number of quality students would appear to be particularly great in the Rocky Mountain area.

(4) The strengthening of research and manpower resources in low-energy physics is clearly required for many other important purposes in science and engineering. The justification for expanding research and teaching of atomic physics does not depend on the requirements of astrophysics; atomic physics is inherently important. However, astrophysics offers many exciting problems which stimulate progress in atomic physics. Indeed, in many cases the two subjects are nearly indistinguishable, which is the reason for describing both under the title "laboratory astrophysics."



Effect of Mortar Properties on the Strength of Masonry

THE INCREASING USE of mortars containing air-entraining masonry cements has prompted a Bureau investigation of the physical properties of these mortars and cements, and the effects of mortar properties on masonry walls. In the study, apparatus and methods were developed for making flexural and racking tests on large-scale wall specimens. A laboratory test was also devised for small specimens to determine the bond strengths of mortar to masonry units.

Data obtained from the investigation showed a relationship between the compressive and bond strengths of the mortars used and the compressive, flexural, and racking strengths of masonry wall structures. The work was jointly sponsored by manufacturers of air-entraining portland cements and the Bureau. C. C. Fishburn, representing the National Research Council while on leave from the Bureau, directed the investigation.[1]

Materials Used in Construction

Three masonry cements, two of which were blends, and a laboratory-prepared cement were used in each of two types of mortars for specimen construction. The four mortars of one type contained 1 part of cementing material to three parts of sand, by volume, and the four mortars of the other type were richer, containing 1 and one-half parts of cementing material to four parts of sand, by volume. The amount of water used was adjusted to produce mortars having as wet a consistency as could be handled by the mason. Initial flows of these mortars ranged from 135 to over 150 percent.

One hundred and fourteen walls, 8 ft high and either 4 or 8 ft long, were constructed; 58 walls were made of 8-in. thick hollow concrete blocks; and the remainder were composite walls containing a 4-in. thick facing of clay bricks and a 4-in. thick backing of hollow concrete blocks. The concrete blocks were conditioned to equilibrium at a minimum relative humidity of 50 percent. The bricks were immersed in water to reduce their rate of absorption from about 0.6 oz per minute when dry to about 0.2 oz when used in wall construction.

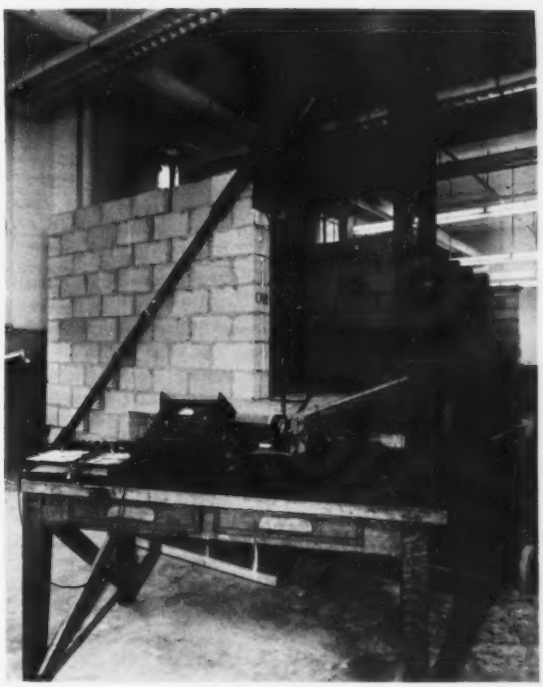
Bond Strength of Mortars

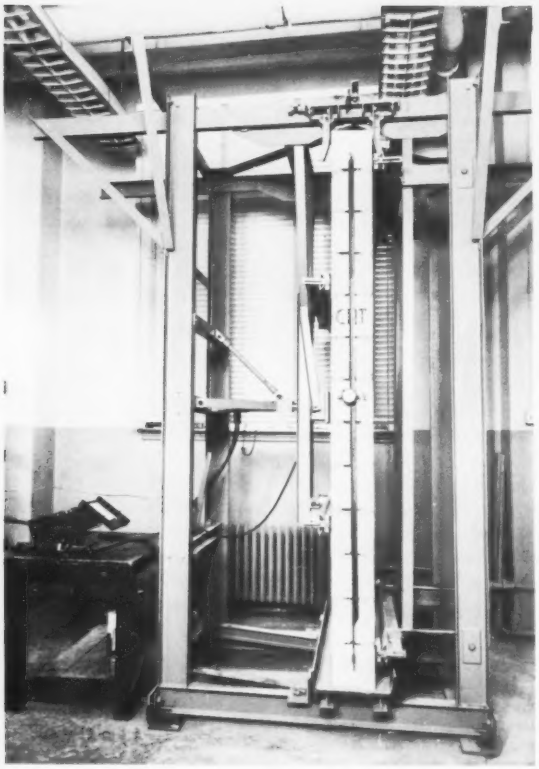
Crossed-brick couplets, assemblies of concrete block, and composite assemblies were also made of the same materials as were used in the walls. These small-scale specimens were employed in studying the bond strengths of the mortars. Special devices were used to measure the tensile bond strengths of the brick couplets and the flexural bond strengths of the assemblies. These measurements served to establish a relationship between the bond strengths of the mortars and the flexural and racking strengths of the walls.

Wall Construction

Masonry units were laid in furrowed mortar beds. The head joints between the units were buttered with mortar only at the outer wall faces. A $\frac{3}{8}$-in. thick mortar parging was applied to the back of the brick facing of the composite walls, and the two tiers were bonded together with a brick header course placed at every seventh brick course. The bed joints between the concrete block courses bridged the collar joint between the two tiers and abutted the mortar parging.

Top of page: **A composite wall specimen of clay brick and hollow concrete block under construction.** *Below:* **Equipment used to determine the racking strengths of masonry walls. Note (in specimen at left) that failure was in bond and tended to follow a step-wise pattern across the wall section.**





Left: **Test apparatus designed to determine the flexural strengths of masonry wall structures. A concrete masonry wall is ready for test.** *Above:* **Typical flexural bond failure between courses of stretcher brick in a composite wall. Note that the bond of mortar in bed joints between stretcher courses appears to be greater at the top than at the bottom of the bed.**

Method of Test of Wall Constructions

Compressive, racking, and flexural loads were applied to the walls in successive increments and reduced to zero or near zero after each increment. Observations were made of linear displacement and deflection before and after application of each load increment. The walls used in the compressive strength tests were loaded on lines located one-third of the wall thickness from the back face of the wall.

A loading apparatus was devised for the racking load tests in the form of a yoke consisting of two steel side bars connected at the ends to steel shoes. These shoes were placed at diagonally opposite corners of the wall. The steel frame used in the flexural tests was fitted with flexible lateral load and support devices. The walls were supported on a freely revolving roller.

Manner of Failure of Masonry Walls

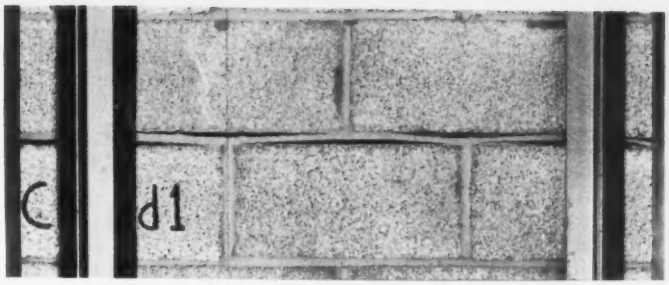
The concrete block walls subjected to compressive load exhibited cracks in the cross webs of the blocks in the top course and directly beneath the load line. Cracks were first noted at about 60 percent of maximum load, and maximum load was reached when the cracks had progressed downward through two or three block courses. The composite walls in these tests failed by crushing of the face shells of the concrete blocks in the upper courses where the effects of load eccentricity were greatest.

All of the masonry walls subjected to racking and flexural loads failed in the bond between the mortar and the masonry units. The flexural load tests on the concrete masonry walls showed that the tensile strength of the mortar at joint intersections was greater than the bond strength of the mortar to the face shells of the concrete blocks.

Flexural load tests on the composite walls tested with the brick facing in tension showed that the mortar bond in bed joints between stretcher courses was greater at the top of the bed than at the bottom. Generally, the incidence of failure in the composite walls appeared to be relatively greater at mortar beds laid adjacent to header brick courses than at beds between stretcher brick courses.

Compressive Strength

The compressive strengths of both types of wall constructions generally increased with the compressive strengths of the mortars. However, the differences in compressive strengths of the two types of mortar were greater than corresponding differences in wall strengths. The compressive strength of the richer mortars approached that of the concrete in the face



Typical failure of a concrete masonry wall subjected to flexural load.

shells of the blocks, and the compressive strengths of the walls containing these mortars were probably limited by the strength of the concrete in those face shells which were subjected to the maximum effects of load eccentricity. The concrete block walls were about half as strong in compression as were the composite walls.

The secant modulus of elasticity at a compressive load of 100 psi on the gross wall area ranged from 530,000 psi for the concrete block walls containing the lowest compressive strength mortar to 1,180,000 psi for the composite walls containing the strongest mortar. For like stresses on the gross wall area and for similar mortars, the modulus of elasticity in compression of the composite walls was twice that of the concrete block walls. Both the shortening strain and the ratio of set to shortening strain were affected by the bearing stresses between the mortars and the face shells of the concrete blocks, as well as by the relative compressive strengths of the mortars and of the concrete in the blocks.

Racking Strength

The data obtained indicate a fairly consistent relationship between the racking strength of the walls and the bond strength of the mortars. A secondary and much less consistent relationship was noted between wall strength and the compressive strength of the mortars. However, it should be pointed out that these relationships may hold only for tests made on specimens built with very wet-consistency mortars. Had the mortars been of a drier consistency, their compressive strengths would have been greater but both the racking strength of the walls and the bond of the mortars to the units might have been considerably less. Average racking strength of the composite walls was nearly 3 times that of the concrete block walls built with similar mortars.

Flexural Strength

There was a fairly consistent relationship between the flexural strengths of both types of walls and the bond strengths of the mortars used. The flexural bond strength of small-scale block assemblies cured in laboratory air with the walls showed good agreement with the flexural strength of the walls themselves. Block assemblies cured under cover for one week were stronger in bond than were the uncovered specimens, probably because of the higher relative humidity of the ambient air under cover. This result emphasizes the influence of proper curing conditions on the flexural strength of concrete masonry.

The flexural strength of composite walls with the concrete block backing in tension was as great as, or slightly greater than, was that of similar walls tested with the brick facing in tension. Generally, the composite walls were about twice as strong in flexure as were the concrete block walls.

At stresses up to half of maximum load, the rigidity of the walls tended to increase with the bond strength of the mortar. At stresses up to about 10 psi on the gross area basis, the concrete block walls were stiffer than were the composite walls. Wall deflection was directly affected by and increased with the number of bed joints in the tensile face of the masonry.

[1] *For further technical details, see NBS Mono. 36,* Effects of mortar properties on strength of masonry, *by Cyrus C. Fishburn, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., for $.30.*

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Vol. **46,** No. 5, May 1962. 15 cents. Annual subscription: $1.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Basic Radio Propagation Predictions for August 1962. Three months in advance. CRPL–213, issued May 1962. 15 cents. Annual subscription: $1.50; 50 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

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Publications (Continued)

Current Issues of the Journal of Research

Section A. Physics and Chemistry, Vol. **66A**, No 3, May–June 1962.

Glass filters for checking performance of spectrophotometer-integrator systems of color measurement. H. J. Keegan, J. C. Schleter, and D. B. Judd.

Calibration of small grating spectrometers from 166 to 600 cm^{-1}. L. R. Blaine, E. K. Plyler, and W. S. Benedict.

Franck-Condon factors to high vibrational quantum numbers II: SiO, MgO, SrO, AlO, VO, NO. R. W. Nicholls.

Oxidation of aldoses with bromine. H. S. Isbell.

An analysis of the solid phase behavior of the normal paraffins. M. G. Broadhurst.

Methylene groups in determination of disulfide and methylene sulfide crosslinks in polycaprolactam fibers. S. D. Bruck.

Purification by automatic gas chromatography. M. Tenenbaum and F. L. Howard.

High resolution investigation of some infrared bands of carbon disulfide. D. Agar, E. K. Plyler, and E. D. Tidwell.

Section B. Mathematics and Mathematical Physics, Vol. **66B**, No. 2, Apr.–June 1962

Hindsight technique in machine translation of natural languages. I. Rhodes and F. L. Alt.

An extension of Jensen's theorem for the derivative of a polynomial and for infrapolynomials. O. Shisha.

Two matrix eigenvalue inequalities. S. Haber.

Graphs for determining the power of Student's *t*-test. M. C. Croarkin.

Section C. Enginering and Instrumentation, Vol. **66C**, No. 2, Apr.–June 1962

Effect of vibration and shock on unsaturated standard cells. R. J. Brodd and W. G. Eicke, Jr.

Experiments on the burning of cross piles of wood. D. Gross.

Transfer of NBS X-ray beam calibrations. J. S. Pruitt, A. Allisy, G. Joyet, W. Pohlit, M. Tubiana, and C. Zupančič.

Identification of metallurgical reactions and their effect on the mechanical properties of 17–7 PH stainless steel. H. C. Burnett, R. H. Duff, and H. C. Vacher.

The ideal Lovibond color system. D. B. Judd, G. J. Chamberlin, and G. W. Haupt.

Systems of electrical units. F. B. Silsbee.

Section D. Radio Propagation, Vol. **66D**, No. 3, May–June 1962

A theory of radar reflections from a rough moon. D. F. Winter.

A lunar theory reasserted. K. M. Siegel and T. B. A. Senior.

Statistical distribution of the amplitude and phase of a multiply scattered field. P. Beckmann.

Amplitude distribution for radio signals reflected by meteor trails, II. A. D. Wheelon.

High resolution pulse measurements of meteor-burst propagation at 41 Mc/s over a 1,295-km path. R. J. Carpenter and G. R. Ochs.

Ionospheric irregularities and long-distance radio propagation. H. A. Whale.

On the role of the process of reflection in radio wave propagation. F. du Castel, P. Misme, A. Spizzichino, and J. Voge.

Correlation between hourly median scattered signals and simple refractivity parameters. A. S. Dennis.

Observations of radio wave phase characteristics on a high-frequency auroral path. J. W. Koch and W. M. Beery.

Diurnal and seasonal changes in structure of the mid-latitude quiet ionosphere. J. W. Wright.

Schumann resonances of the earth-ionosphere cavity—extremely low frequency reception at Kingston, R.I. C. Polk and F. Fitchen.

Propagation of plane electromagnetic waves past a shoreline. J. Bazer and S. N. Karp.

Currents induced on the surface of a conducting circular cylinder by a slot. G. Hasserjian and A. Ishimaru.

Nonperiodicals

Tables of spectral-line intensities. Part I. Arranged by elements, W. F. Meggers, C. H. Corliss, and B. F. Scribner, NBS Mono. 32, Pt. I (Dec. 29, 1961) $4.00.

Radiation patterns in the lower ionosphere and Fresnel zones for elevated antennas over a spherical earth, R. G. Merrill and W. V. Mansfield, NBS Mono. 38 (Apr. 2, 1962) 70 cents.

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An ultraviolet multiplet table, C. E. Moore, NBS Cir. 488, Sections 3, 4, and 5 (Apr. 6, 1962) Section 3, 60 cents; Section 4, 45 cents; Section 5, 30 cents.

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Patents

The following U.S. Patents have recently been granted on NBS inventions and, except as noted, are assigned to the United States of America as represented by the Secretary of Commerce.

3,016,704 Jan. 16, 1962 Apparatus for Introducing a Reactive Chemical into the Pilot Zone of a Combustion Chamber—Richard L. Duncan, David J. Miller, Frank R. Caldwell, Fillmer W. Ruegg, and Ernest F. Fiock (Navy).

3,019,150 Jan. 30, 1962 Tape Capacitor—Benjamin L. Davis and Wilbur G. Nyberg (Navy).

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